

COST ESTIMATE FOR CONVERSION OF HONOLULU'S RAIL TO MAGNETICALLY LEVITATED

Version 2

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Bill 42

Executive Summary

This report estimates the costs of completing Honolulu's rail by immediately stopping the present steel-wheel on steel-rails approach, and switching forthwith to the American designed magnetically levitated (maglev) approach. The transition is seamless, where existing guideways and other constructed elements can be used as is, while the rail cars are adapted to use maglev magnets without changing the car's design. As such, Hitachi-Italy can continue to be the rail car suppliers, but with a modified contract.

The report is divided into four parts, as given on pages 1 and 2:

- i. Part 1a: Existing contracts and constructions for the 10 miles from East Kapolei to Aloha Stadium
- ii. Part 1b: Conversion of the existing track to maglev
- iii. Part II: Construction of a new guideway for the 10 miles from Aloha Stadium to Ala Moana Center
- iv. General costs that are spread over the 20 miles, such as Right of Way (R-O-W) acquisition, professional services, and finance charges

The costs are put together in the following manner:

- a) Costs of all existing contracts and construction are taken from the HART website of procured contracts and HART announcements in the Honolulu Star-Advertiser
- b) Costs of new maglev guideways and rail cars are taken from the estimates put together by the inventors of superconducting maglev, who have written two books on the subject, were supported greatly in the U.S. Congress by the late senator Patrick Moynihan, and who continue to improve their inventions, such that they are now in the 2nd generation of maglev while other countries who adopted maglev successfully – Japan, China, and South Korea – used only 1st generation designs.
- c) Appropriate inflation factors (3.6%/year) and city cost indexes (1.25 for Honolulu) have been incorporated to transfer costs to Honolulu for the year 2017.

Each item in page 1-2 is given a supporting document that explains how the costs were derived. Sources for each item are given in the supporting documents. Hence, there is validity for each cost item. Those supporting documents are listed in the Table of Contents and included in this report. The costs are real for the most part, having been incurred by HART, while other costs are based on reliable estimates and parametric costing based on information from the inventors of maglev and general cost principles. The supporting documents further explain how the costs have been calculated, wherever relevant. Relevant details of costs have either been circled or placed within brackets.

In brief, it is seen that Part 1a costs \$2,048.97 million; Part 1b costs \$328.87 million; Part 2 costs \$1,552.97 million; and the category of General Costs come in at \$1,816.00 million. The total costs, after considering new overheads, amounts to **\$5,860.33 million**.

The appendices carry a map of the alignment, where Parts I and II are handwritten on the document. The appendices also carry two drawings to illustrate how existing rail lines can be converted to maglev, and how a new line will be configured.

Basically, it is important to keep in perspective that the guideway of maglev is lighter and cheaper owing to the maglev trains literally “flying” above the rails. In addition, maglev technology results in less frequent maintenance because there is no friction between steel wheels and steel rails, meaning that wear and tear and other shock forces are less in maglev.

The technology to convert to maglev can easily be applied by the talent pool in the state after proper guidance on the subject, which is only restricted to the magnets in the undercarriage of the rail cars, the other guideway and cars being of traditional technology. It must be realized that the whole conversion is very doable and beneficial.

Hence, there is absolutely no reason for the legislature to appropriate additional funds for the completion of rail. To the contrary, about \$940 million will be left over in the kitty out of the \$6.8 billion that can be used for multiple other purposes, including making an extension West of East Kapolei or East of Ala Moana Center. Note that it is absolutely not necessary to reduce the number of stations along the route, which will cut ridership and render the project a failure.

Lastly, we should mention that magnetically levitated trains make less noise than steel wheel on steel rails, have a smoother ride, and brake and start more smoothly. Very importantly, perhaps, maglev is 21st century technology, while steel wheel on steel rails is 19th century technology. We hope that the legislature, City, and State will see the wisdom in maglev, without compromising anything. It must be mentioned that maglev rail will itself be a likely attraction for visitors, not to mention the increased ridership on that account, thereby boosting State and City revenues.

This report was prepared under the guidance of Professor Amarjit Singh, with data and input supplied by systems analyst Lieutenant Colonel Frank Genadio (USAF, Retired), and ably put together by engineers Scott Dona and Manuela Melo.

With the use of the appropriate technology, there is hope for Honolulu rail.

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ESTIMATE OF MAGLEV COSTS

Part I a East Kapolei to Aloha Stadium - 10 miles			
#	Supporting Document #	Item	Cost (million \$)
1	1a.SD1	Cars	\$115.20
		Design and Systems for Cars, Shipping for Cars, and Overhead	\$229.30
		O&M for Cars	\$83.50
2	1a. SD2	Stations	\$256.20
3	1a.SD3	M&S	\$281.77
4	1a. SD4	Guideway	\$579.50
5	1a. SD5	Sitework	\$503.50
TOTAL			\$2,048.97

Part I b Convert Existing System to Maglev: East Kapolei to Aloha Stadium - 10 miles			
#	Supporting Document #	Item	Cost (million \$)
1	1b.SD1	Guideway Panel Installation + Fabrication	\$141.60
2	1b.SD2	Modification of Existing M&S Facility to Accommodate Maglev	\$42.27
3	1b.SD3	Maglev Cars - Modification to already Built 40 Cars	\$120.00
4	1b.SD4	Renegotiation with Hitachi Italy - Undertake through Negotiations	\$25.00
TOTAL			\$328.87

Part II Aloha Stadium to Ala Moana Center: Total New Maglev Guideway - 10 miles			
#	Supporting Document #	Item	Cost (million \$)
1	2.SD1	New Maglev Guideway Including Sitework	\$518.38
2	2.SD2	Maglev Cars - deliver 40 New Maglev Cars	\$287.99
3	2.SD3	Design and Systems for Cars, Shipping for Cars, and Overhead	\$229.30
4	2.SD4	O&M for Cars	\$83.50
5	2.SD5	Stations	\$433.80
TOTAL			\$1,552.97

General General Costs for the Entire 20 miles			
#	Supporting Document #	Item	Cost (million \$)
1	G.SD1	Pearl Highland Transit Center - Bus Services	\$280.00
2	G.SD2	Professional Services	\$1,123.00
3	G.SD3	R-O-W Acquisition	\$198.00
4	G.SD4	Finance Charges	\$215.00
TOTAL			\$1,816.00

Summary	
Part I a	\$2,048.97
Part I b	\$328.86
Part II	\$1,552.98
General	\$1,816.00
TOTAL	\$5,746.81
New overheads 10% - For Part I b and Part II (2.SD1 and 2.SD2)	\$113.52
TOTAL	\$5,860.33

Supporting Document # 1a.SD1
Part I a

CARS, DESIGN-BUILD FOR CARS, AND OPERATIONS AND MANAGEMENT

Item		Price (million \$)	Calculations	Source
(i)	Cars	\$115.20	$\$2 \text{ M} \times (1.036)^4 \times 1.25 = \$2.88 \text{ M / car};$ $\$2.88 \text{ M} \times 40 \text{ cars} = \115.2 M 1.25 = Transport and shipping factor 1.036 = inflation factor / year	Danby, G., Powell, J., Coullahan, R., Fazio, E., Maise, G., Rather, J., and Jordan, J. (2013). "Maglev America: How Maglev will Transform the World Economy". p. 205.
(ii)	Design and Systems for Cars, Shipping for Cars, and Overhead	\$229.30	$\$573.8 \text{ M for 80 cars};$ $(\$573 \text{ M} - \$115.20 \text{ M}) \div 2 = \$229.30 \text{ for 40 cars}$	HART, Honolulu Authority for Rapid Transportation. AGREEMENT FOR DESIGN-BUILD-OPERATE-MAINTAIN SERVICES CONTRACT No. CT-DTS1100194. November, 2011. Available at: http://hartdocs.honolulu.gov/docushare/dsweb/Get/Document-14729/Agreement.pdf . Accessed April, 2017.
(iii)	O&M for 40 Cars	\$83.50	Intermediate O & M (2021 through 2025) $\$167 \text{ M for 80 cars};$ $\$167 \text{ M} \div 2 = \$83.5 \text{ M for 40 cars}$	
TOTAL		\$428.00		

Documents attached
 Appropriate prices circled

Figure 7.1 shows a map of the New York City Subway System. It has by far the highest ridership in the US, accounting for 25% of total public transit ridership on all modes, including heavy rail, commuter rail, light rail, buses, trolleys, etc. In the heavy rail category, i.e. subways, BART, DC metro, etc., the NYC Subway ridership is 68% of total US ridership. Table 7.6 summarizes the principal parameters of the NYC Subway System. The annual ridership per track mile (one direction) is very high, approximately 2.4 Billion passengers divided by 842 track miles, or 2.85 million passengers per track mile. For a Maglev adaptation cost of 4 million dollars per track mile, paid back in 20 years, this amounts to only 7 cents per passenger trip, a minor cost compared to the present operating cost – fare revenues plus subsidies – of \$1.40 per passenger trip. In fact, the reduction in trip cost that will be made possible by Maglev will be much greater than the adaptation cost.

Only 60% of total track mileage is in underground tunnels, with 40% being elevated on embankments, or in open cuts. The 40% portion will be simpler to adapt for Maglev operations, because of the easier access. However, the underground portion can be readily adopted for Maglev using specially equipped subway cars, as described later in the chapter.

The cost of new subway cars is 2 million dollars each. The projected cost of the Maglev cars, essentially a subway car with superconducting magnets located under the car's floor, is 5 million dollars each. The Maglev car will be lighter than the present subway cars, which range in weight from about 70,000 lbs to 85,000 pounds, because the Maglev cars will use lighter weight materials and are not subjected to the high stresses and bumping that existing subway cars experience. A unit weight of approximately 40,000 lbs empty and 60,000 pounds loaded appears achievable for the Maglev cars.

Passenger space inside present subway cars is very small. The R/60 car has a maximum capacity of 44 seated passengers and 202 standing passengers. With a total floor area of $75 \times 10 = 750$ square feet, this corresponds to a floor area of 3 square feet per passenger. Visualize 11 people standing on a 4 foot by 8 foot dining room table. Maglev cars will have more room, since they are more flexible in meeting peak passenger loads, and have higher average speed.

Honolulu High-Capacity Transit Corridor Project

The third NTP ("NTP #3") is anticipated to be issued to construct, install, test and demonstrate the Core Systems operations leading to multiple segment openings for Passenger Service, as is defined in Part 2, Special Provisions ("SP") SP-4.1.

Subsequent NTPs may be issued for commencement of operations and maintenance and for Work identified in Contract amendments. All NTPs shall be issued in support of the accepted Baseline Schedule (as Proposed) in compliance with the schedule required dates defined in SP-4.1 and attached to this Contract in Part 9.

5. This is a firm fixed-price contract, and subject to the provisions of this paragraph and in accordance with Chapter 6 of the GCDB, as amended by Chapter 6 of the Special Provisions, HART agrees to pay the CORE SYSTEMS CONTRACTOR, for the satisfactory performance and completion of the Work, the payments in accordance with the Schedule of Milestones. The aggregate amount of these lump sum payments shall not exceed ONE BILLION THREE HUNDRED NINETY-SEVEN MILLION THREE HUNDRED EIGHTY-SEVEN THOUSAND NINETY-THREE AND 00/100 DOLLARS (\$1,397,387,093.00). The lump sum payments for services and the Work performed under the Contract are all inclusive of direct labor, overhead, general and administrative expenses, other direct costs, subcontractor costs, fixed fees, and all applicable taxes, State general excise and use tax (GET) and county one-half percent (0.5%) GET Surcharge.

The total lump sum payments consist of the following:

\$573,782,793 for the Design-Build lump sum;
\$166,974,503 for Intermediate O&M periods;
\$339,056,303 for the first full five-year O&M period;
\$317,573,494 for the optional five-year O&M period unless terminated by HART.

At the end of the first full five-year O&M period, the CORE SYSTEMS CONTRACTOR's O&M performance on the O&M portion of the Work will be evaluated by HART. HART may terminate the Agreement at the end of the first full five-year O&M period without any further obligations to HART if HART, in its sole discretion, determines that the CORE SYSTEMS CONTRACTOR's O&M performance is unsatisfactory. Such termination of the Agreement shall be in writing from HART to the CORE SYSTEMS CONTRACTOR. Any funds remaining at the end of this Agreement shall revert back to HART.

In accordance with the paragraphs above, the total aggregate amount of ONE BILLION THREE HUNDRED NINETY-SEVEN MILLION THREE HUNDRED EIGHTY-SEVEN THOUSAND NINETY-THREE AND 00/100 DOLLARS (\$1,397,387,093.00) is established as the maximum payable under this Contract and is subject to the Special Provisions and the GCDB, including the provisions thereof relating to reducing or increasing the compensation of the CORE SYSTEMS CONTRACTOR.

6. By signing below, the CORE SYSTEMS CONTRACTOR hereby certifies that, to the best of its knowledge and belief, cost or pricing data, as defined in Section 3-122-122, HAR, and submitted pursuant to Section 3-122-125, HAR, is accurate, complete, and current as of the date of this Contract.

7. Unless otherwise agreed in writing when notice is to be given to HART, it shall be mailed or delivered to:

Supporting Document # 1a.SD2
Part I a

STATIONS

Item	Price (million \$)	Calculations	Source
Stations	\$256.20	For 9 stations; Sum of all stations from "East Kapolei" to "Aloha Stadium" minus "Pearl Highlands TC"	HART, Honolulu Authority for Rapid Transportation. Interim Plan. Available at: http://hartdocs.honolulu.gov/docushare/dsweb/Get/Document-19327/20160930-hart-interim-plan.pdf . Accessed April, 2017.

Documents attached
Appropriate prices circled

September 2016

Option #3

Construct Project as far as funding allows

Actual or Estimated Cost of Each Station

East Kapolei	\$	17.7M	Airport	\$	32.5M
UH West O'ahu	\$	22.2M	Lagoon Drive	\$	22.3M
Ho'opili	\$	14.1M	Middle Street	\$	45.9M
West Loch	\$	41.0M	Kalihi	\$	30.2M
Waipahu	\$	35.2M	Kapalama	\$	33.0M
Leeward CC	\$	12.0M	Iwilei	\$	31.8M
Pearl Highlands TC	\$	280.0M	Chinatown	\$	41.1M
Pearl Highlands	\$	47.1M	Downtown	\$	60.1M
Pearlridge	\$	36.4M	Civic Center	\$	37.4M
Aloha Stadium	\$	30.5M	Kaka'ako	\$	27.9M
Pearl Harbor	\$	26.0M	Ala Moana	\$	45.6M

EXHIBIT F

HONOLULU RAIL TRANSIT PROJECT

WWW.HONOLULUTRANSIT.ORG

HART
HAWAIIAN RAIL TRANSIT AUTHORITY

Supporting Document # 1a.SD3
Part I a

MAINTENANCE AND STORAGE (M&S)

Item	Price (million \$)	Calculations	Source
M&S	\$281.77	-	HART, Honolulu Authority for Rapid Transportation. March Monthly Progress Report. Available at: http://hartdocs.honolulu.gov/docushare/dsweb/Get/Document-20452/201703-monthly-progress-report-low-res.pdf . Accessed April, 2017.

Documents attached

Appropriate prices circled

Supporting Document # 1a.SD3

Honolulu Rail Transit Project Monthly Progress Report

March 2017

D. Maintenance and Storage Facility (MSF)

Contract No.: DB-200

Contractor: Kiewit/Kobayashi Joint Venture (KKJV)

Contract Start Date: July 2011

Actual Substantial Completion: July 2016

Project Description: The MSF contract consists of the Operations and Servicing Building (OSB), Maintenance of Way (MOW), Train Wash Facility (TWF) and Wheel Truing Building (WTB). In addition to the four (4) facility buildings, MSF includes rail procurement, special trackwork, ties, third rail and other track material for the four guideway segments on the project.

% Complete		Schedule Status
Based on Expenditures*	100%	Substantial
Early Plan*	100%	Completion
Late Plan*	100%	Obtained**
*Data as of Feb. 24, 2017.		
**Further explanation is provided in the Schedule section.		

COST INFORMATION:

Original Contract:	\$195,258,000	Incurred-to-Date:	\$281,753,403
Current Contract Value ¹ :	\$281,775,032	Incurred in February:	\$6,936,740
¹ Current Contract Value = Original contract value + executed Change Orders			

DBE Participation	
Actual DBE Participation:	\$710,472
DBE % Attained:	0.26%

February Change Orders		
Change No.	Description	Amount (\$)
0049	Layout Direct Fixation Ballasted Turnouts	\$322,782
0050	Additional Design Review Cycles	\$987,402
0051	Extended Design Management & Interface	\$892,880
0052	Additional Design Services Escalation	\$50,187
0053	OSB Atrium Fire Rating	\$615,720
0054	Inadequate Water Pressure	\$1,092,670
0055	Added Comm Rooms for OSB, MOW & TWF	\$215,728
0056	OCC Layout and Work Stations	\$11,600
0057	Train Auxiliary Panel Load	\$153,456
0058	Rework of Site due to AIS	\$18,087
0060	OSB Reconfiguration	\$249,088
0061	Train Wash Facility Shortening	\$667,200
0062	Payment for Utility Services	\$840,672
0063	Yard Storage Track Crossing	\$305,800
0059	Waipahu HS Light Pole Conflict	\$76,728
Cumulative to Date		\$86,517,032

SCHEDULE:

- The MSF project is currently in the close-out stage. The new target date for final acceptance is May 1, 2017, for the following key reasons:
 - As-Built Drawings.
 - Final close-out documentation.
 - Isolation Pad/Shims delivery and installation by May 1, 2017.

MSF Construction Status 99.9% Complete Overall as of 03/15/17	
Element	% Complete*
OSB	99.9%
MOW Building	99.9%
WTB	99.9%
TWF	99.9%
Rail	99.9%
Paving	100%

*Not including testing and commissioning.

**Supporting Document # 1a.SD4
Part I a**

GUIDEWAY

Item	Price (million \$)	Calculations	Source
Guideway	\$579.50	For 10 miles of guideway from East Kapolei to Aloha Stadium; $\$1159\text{M} / 20 \text{ miles} \div 2 =$ $\$579.5\text{M} / 10 \text{ miles}$	HART, Honolulu Authority for Rapid Transportation. Rail Facts. Available at: http://hartdocs.honolulu.gov/docushare/dsweb/Get/Document-18755/201603-rail-update-hart-facts.pdf . Accessed April, 2017

**Supporting Document # 1a.SD5
Part I a**

SITWORK

Item	Price (million \$)	Calculations	Source
Sitework	\$503.50	For 10 miles of sitework from East Kapolei to Aloha Stadium; $\$1007\text{M} / 20 \text{ miles} \div 2 =$ $\$503.5\text{M} / 10 \text{ miles}$	HART, Honolulu Authority for Rapid Transportation. Rail Facts. Available at: http://hartdocs.honolulu.gov/docushare/dsweb/Get/Document-18755/201603-rail-update-hart-facts.pdf . Accessed April, 2017

Documents attached
Appropriate prices circled



HONOLULU AUTHORITY for RAPID TRANSPORTATION

HART FACTS-MARCH 2016

HART CEO Dan Grabauskas answers community questions about rail transit.

QUESTION:

What is the status of the production of HART's rail vehicles?

4

DAN GRABAUSKAS:

Our first four rail cars are in final assembly at the Hitachi plant in Pittsburg, California and are scheduled to be delivered here in Honolulu during the last week of this month. Our 4-car trains will be air conditioned, and passengers will have free Wi-Fi access. Trains will run from 4 a.m. to midnight and will arrive at stations every 5 minutes during the morning and evening rush hours, and every 11 minutes during the rest of the day. Each train will be equipped with safety and security features, including closed-circuit television cameras and call boxes. Passengers will be able to bring luggage, strollers, bicycles and surf boards aboard. The cars will undergo some initial testing at the Rail Operations Center in Waipahu.

PROJECT REVENUE STATUS As of February 1, 2016	Projections to Date ¹	Collected or Committed to Date	Percentage (of projections)
REVENUE SOURCE:	(in millions)	(in millions)	
Project Beginning Cash Balance (Dec. 2009)	\$ 298	\$ 298	100%
General Excise Tax (GET) Surcharge ²	3,291	1,259	38%
Federal New Starts Funds	1,550	1,056	68%
Other Federal Transportation Funds	214	4	2%
Interest Income	2	9	-
TOTAL	\$5,355	\$2,626	49%

1 - Projections to date from the June 2012 Financial Plan.
2 - Total GET surcharge revenue collected since January 1, 2007, is \$1.59 billion (includes \$378 million collected before December 2009).

PROJECT COST STATUS As of February 1, 2016	Current Budget ¹	Amount Committed ²	Amount Expended ³
	(in millions)	(in millions)	(in millions)
Guideway & Track Elements	\$1,159	\$ 550	\$ 292
Stations, Stops, Terminals, Intermodal	419	302	5
Support Facilities; Yards, Shops, Admin	115	115	92
Sitework & Special Conditions	1,007	730	569
Systems	249	234	40
Vehicles	191	191	36
SUB-TOTAL*	\$3,140	\$2,122	\$1,033
Right-of-Way (ROW), Land, Existing Improvements	\$ 198	\$ 104	\$ 100
Professional Services (e.g., Planning and Design)	1,123	1,049	787
Contingency	487	7	1
Finance Charges	215	0	0
SUB-TOTAL*	\$2,024	\$1,160	\$ 888
TOTAL*	\$5,164	\$3,282	\$1,921

1 - Current Budget reflects the June 2012 Baseline Budget with executed Budget Transfers.
2 - Approved contract value. 3 - Portion of the work that has been paid.
* All costs are rounded to the millions therefore subtotals may not add up to the amounts shown.

DID YOU KNOW? HART has ordered a fleet of 80 rail cars.

Supporting Document # 1b.SD1
Part I b

GUIDEWAY PANEL INSTALLATION AND FABRICATION

Item	Price (million \$)	Calculations	Source
Guideway Panel Installation + Fabrication	\$141.60	$\$3,880/\text{panel} \times 1056$ panels/mile $\times 10$ miles $\times 2$ ways $\times (1.036)^4 \times 1.5$ 1.5 = Honolulu city cost index factor + Shipping from the Mainland	Danby, G., Powell, J., Coullahan, R., Fazio, E., Maise, G., Rather, J., and Jordan, J. (2013). "Maglev America: How Maglev will Transform the World Economy", p. 14 and p. 252.

Documents attached

The conclusion? HSR routes must be heavily subsidized. At best, there would be only a few isolated routes in the US, e.g., Maybe LA to SF, Boston to Washington, DC, Chicago to St. Louis. Only a small fraction of the public would live in the areas served, and only a small fraction of them would afford the fares. Everybody else would pay taxes to support the few HSR lines. Very unfair. HSR cannot become a National Network like highways and airways, and could only provide a tiny fraction of US transport needs.

Maglev 2000, on the other hand, can be constructed as a 29,000 mile National Network by private investment without government subsidies. 70% of the public would live within 15 miles of a Maglev station, from which they could reach any point in America at low cost – much cheaper than driving or flying.

Q4: How does Maglev 2000 travel along existing railroad and subway tracks?

A4: The capability to adapt existing railroad and subway tracks for travel by magnetically levitated and propelled vehicles at very low cost is a unique feature of the 2nd generation Maglev 2000 system. 1st generation Maglev systems cannot do this. To travel in densely populated urban and suburban areas, they have to construct new, very expensive guideways, tear down existing structures and acquire rights of way at great cost. It would repeat Boston's very expensive "Big Dig".

[In contrast, Maglev 2000 attaches thin panels of aluminum loops to the cross ties of existing railroad and subway tracks. The cost is very low, 4 million dollars per mile of track (1-way), 8 million dollars per mile (2-way). The quadrupole magnets on moving Maglev 2000 vehicles induce currents in the aluminum loops that levitate them. The levitation is strongly stable. Applied AC current in a second set of aluminum loops in the panels magnetically propels the Maglev 2000 vehicles.]

The aluminum loop panels can be installed during periods when conventional trains and subway cars are not using the tracks, so that existing service is not disrupted. Conventional trains and subway cars can continue to use the tracks after Maglev 2000 vehicles start operating, given appropriate scheduling.

By adapting existing railroad tracks, 300 mph intercity Maglev vehicles can transition from their elevated monorail guideways to the existing tracks for travel at reduced speed in densely populated urban and suburban areas, serv-

Supporting Document # 1b.SD1

MAGLEV AMERICA

Adapting the Long Island Railroad for Maglev

Table 8.10 Design Parameters and Cost Components for Guideway Panels that Adapt Existing Railroad Tracks for Maglev Operation.

Design Parameters
<ul style="list-style-type: none"> Panel Dimensions – 10 feet long, 39 inches wide, 3 inches thick Aluminum loops for Maglev vehicle levitation, stability, and propulsion inside panel. 500 pounds of aluminum conductor per panel 0.8 cubic yards of polymer concrete per panel that encloses the aluminum loops
Cost of Materials and Fabrication into Panel
<ul style="list-style-type: none"> Aluminum material cost is \$1 per pound, fabricated into panel, cost is \$2 per pound. 500 pounds per panel costs \$1,000. Total Cost for Fabricated Panel is \$1800.
Labor cost of Installation
<ul style="list-style-type: none"> 4 man Phase 2 crew installs 2 panels per hour, equals 2 man hours per panel 4 man Phase 1 and 4 men Phase 3 crews also count for labor costs resulting in 6 person hours total per panel. Direct labor costs, including fringe benefits are \$40 per hour (\$83,000 per year). Direct labor costs are $6 \times 40 = \\$240$ per panel Overhead costs (administrative, etc) are twice: Direct labor costs = \$240 per panel. Total Installation cost is \$480 per panel
Cost of Polymer Concrete overlay on Installed Panel
<ul style="list-style-type: none"> 2 inch thick polymer concrete overlay, 0.5 cubic yards per panel Material cost of polymer concrete @ \$500 per cubic yard = \$250 Installed cost is $2 \times$ material cost = \$500 per panel.
Total Cost of Installed Panel Plus Overlay
<ul style="list-style-type: none"> Total equals panel fabrication cost (\$1,800) plus installation labor cost (\$480) plus overlay cost (\$500) Total is $1800 + 480 + 500 = \\$2780$ per panel.
Contingency addition @ 40 %
<ul style="list-style-type: none"> $0.40 \times \\$2780 = \\1100 Total cost per panel = \$3880 Total number of Panels per Track mile = 1056 (one panel on left side of track, one on right side) Total cost is 4 million dollars per Track Mile.

Supporting Document # 1b.SD2
Part I b

**MODIFICATION OF EXISTING MAINTENANCE AND SERVICE FACILITY TO ACCOMMODATE
MAGLEV**

Item	Price (million \$)	Calculations	Source
Modification of Existing M&S Facility to Accommodate Maglev	\$42.27	$\approx 15\%$ of 281.77 M	Supporting Document # 1.SD3

Supporting Document # 1b.SD3
Part I b

MAGLEV CARS - MODIFICATION TO ALREADY BUILT 40 CARS

Item	Price (million \$)	Calculations	Source
Maglev cars - Modification to Already Built 40 Cars	\$120.00	Add magnets and supports to existing 40 cars ≈ 3 M / car No additional car redesign required	Danby, G., Powell, J., Coullahan, R., Fazio, E., Maise, G., Rather, J., and Jordan, J. (2013). "Maglev America: How Maglev will Transform the World Economy", p. 205.

Document attached

Note: HART will have the option of conversion of steel wheel rail cars or letting them operate as delivered for a period of time on the (currently) existing guideway of ten miles. New maglev rail cars will be able to operate throughout the full 20-mile alignment.

Figure 7.1 shows a map of the New York City Subway System. It has by far the highest ridership in the US, accounting for 25% of total public transit ridership on all modes, including heavy rail, commuter rail, light rail, buses, trolleys, etc. In the heavy rail category, i.e. subways, BART, DC metro, etc., the NYC Subway ridership is 68% of total US ridership. Table 7.6 summarizes the principal parameters of the NYC Subway System. The annual ridership per track mile (one direction) is very high, approximately 2.4 Billion passengers divided by 842 track miles, or 2.85 million passengers per track mile. For a Maglev adaptation cost of 4 million dollars per track mile, paid back in 20 years, this amounts to only 7 cents per passenger trip, a minor cost compared to the present operating cost – fare revenues plus subsidies – of \$1.40 per passenger trip. In fact, the reduction in trip cost that will be made possible by Maglev will be much greater than the adaptation cost.

Only 60% of total track mileage is in underground tunnels, with 40% being elevated on embankments, or in open cuts. The 40% portion will be simpler to adapt for Maglev operations, because of the easier access. However, the underground portion can be readily adopted for Maglev using specially equipped subway cars, as described later in the chapter.

[The cost of new subway cars is 2 million dollars each. The projected cost of the Maglev cars, essentially a subway car with superconducting magnets located under the car's floor, is 5 million dollars each. The Maglev car will be lighter than the present subway cars, which range in weight from about 70,000 lbs to 85,000 pounds, because the Maglev cars will use lighter weight materials and are not subjected to the high stresses and bumping that existing subway cars experience. A unit weight of approximately 40,000 lbs empty and 60,000 pounds loaded appears achievable for the Maglev cars.]

Passenger space inside present subway cars is very small. The R/60 car has a maximum capacity of 44 seated passengers and 202 standing passengers. With a total floor area of $75 \times 10 = 750$ square feet, this corresponds to a floor area of 3 square feet per passenger. Visualize 11 people standing on a 4 foot by 8 foot dining room table. Maglev cars will have more room, since they are more flexible in meeting peak passenger loads, and have higher average speed.

Supporting Document # 1b.SD4
Part I b

RENEGOTIATION WITH HITACHI ITALY

Item	Price (million \$)	Calculations	Source
Renegotiation with Hitachi Italy	\$25.00	Costs to revise drawings and systems ≈ \$25 M; Car design remains the same except for magnet installation. (Price may even be less than \$25 M)	Rough estimate \$25 M Lump Sum

**Supporting Document # 2.SD1
Part II**

NEW MAGLEV GUIDEWAY

Item	Price (million \$)	Calculations	Source
New Maglev Guideway + Sitework	\$518.38	$\$30 \text{ M} \times (1.036)^4 \times 1.5 = \$51.838 \text{ M / mile};$ $\$51.838 \text{ M} \times 10 \text{ miles} = \518.38 M 1.5 = Honolulu city cost index factor + Shipping from the Mainland 1.036 = inflation factor / year	Danby, G., Powell, J., Coullahan, R., Fazio, E., Maise, G., Rather, J., and Jordan, J. (2013). "Maglev America: How Maglev will Transform the World Economy", p. 15.

Document attached

ing multiple stations in the region, without having to build new, very disruptive and expensive guideways in populated areas.

Q5: How much does the 300 mph elevated monorail Maglev 2000 guideway cost to construct?

A5: A 2-way Maglev 2000 monorail guideway built on the right-of-way alongside our Interstate Highways will cost about 30 million dollars per mile. This is substantially lower in cost than 1st generation Maglev systems, which cost in the range of 60 to 100 million dollars per mile.

There are a number of reasons for this:

The 1st generation guideways are much more massive with much more material than the Maglev 2000 monorail. Moreover, they require much more costly field construction. The Maglev 2000 guideway beams, piers, and aluminum loop panels can be mass-produced in factories at low cost. The guideway beams, with their attached panels, and piers can be trucked to the construction site and rapidly erected onto pre-poured concrete footings at very low cost, using conventional cranes. The cost of trucking the beams and piers to the construction site is very low. Maglev 2000 trucked a full-scale 72 foot long guideway beam from its fabrication site in New Jersey to Maglev 2000's laboratory in Titusville, Florida, a distance of approximately 1,000 miles for only a few thousand dollars.

When Maglev 2000 implementation on large scale begins, trucking distances will be less, a few hundred miles at most. Trucking one hundred 100-foot long guideway beams, the number needed per mile for a 2-way guideway, at \$2,000 per beam, is only \$200,000, less than 1 percent of total guideway cost.

The 30 million dollars per 2-way mile of elevated monorail guideway has been projected using detailed analysis of the fabrication cost of the various components, based on material prices, and the experience of Maglev 2000 in fabricating full-scale prototypes of the components.

Q6: Do Maglev 2000 vehicles have to slow down and stop at on-line stations? Can Maglev 2000 serve multiple stations in a region without substantially reducing average travel speed?

**Supporting Document # 2.SD2
Part II**

NEW MAGLEV CARS

Item	Price (million \$)	Calculations	Source
Cars	\$287.99	$\$5 \text{ M / car} \times (1.036)^4 \times 1.25 =$ $\$7.20 \text{ M / car};$ $\$7.20 \times 40 \text{ cars} = \287.99 M for 40 cars 1.25 = Transport and shipping factor 1.036 = inflation factor / year	Danby, G., Powell, J., Coullahan, R., Fazio, E., Maise, G., Rather, J., and Jordan, J. (2013). "Maglev America: How Maglev will Transform the World Economy", p. 205.

Document attached
Appropriate price circled

Supporting Document # 2.SD2

MAGLEV AMERICA

Adapting the NYC Subway for Maglev

Figure 7.1 shows a map of the New York City Subway System. It has by far the highest ridership in the US, accounting for 25% of total public transit ridership on all modes, including heavy rail, commuter rail, light rail, buses, trolleys, etc. In the heavy rail category, i.e. subways, BART, DC metro, etc., the NYC Subway ridership is 68% of total US ridership. Table 7.6 summarizes the principal parameters of the NYC Subway System. The annual ridership per track mile (one direction) is very high, approximately 2.4 Billion passengers divided by 842 track miles, or 2.85 million passengers per track mile. For a Maglev adaptation cost of 4 million dollars per track mile, paid back in 20 years, this amounts to only 7 cents per passenger trip, a minor cost compared to the present operating cost – fare revenues plus subsidies – of \$1.40 per passenger trip. In fact, the reduction in trip cost that will be made possible by Maglev will be much greater than the adaptation cost.

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The cost of new subway cars is 2 million dollars each. The projected cost of the Maglev cars, essentially a subway car with superconducting magnets located under the car's floor, is 5 million dollars each. The Maglev car will be lighter than the present subway cars, which range in weight from about 70,000 lbs to 85,000 pounds, because the Maglev cars will use lighter weight materials and are not subjected to the high stresses and bumping that existing subway cars experience. A unit weight of approximately 40,000 lbs empty and 60,000 pounds loaded appears achievable for the Maglev cars.

Passenger space inside present subway cars is very small. The R/60 car has a maximum capacity of 44 seated passengers and 202 standing passengers. With a total floor area of $75 \times 10 = 750$ square feet, this corresponds to a floor area of 3 square feet per passenger. Visualize 11 people standing on a 4 foot by 8 foot dining room table. Maglev cars will have more room, since they are more flexible in meeting peak passenger loads, and have higher average speed.

**Supporting Document # 2.SD3
Part II**

DESIGN AND SYSTEMS FOR CARS, SHIPPING FOR CARS, AND OVERHEAD

Item	Price (million \$)	Calculations	Source
Design and Systems for Cars, Shipping for Cars, and Overhead	\$229.30	$\$573.8 \text{ M for 80 cars;}$ $(\$573.8 \text{ M} - \$115.20 \text{ M}) \div 2 =$ $\$229.30 \text{ for 40 cars}$	HART, Honolulu Authority for Rapid Transportation. AGREEMENT FOR DESIGN-BUILD-OPERATE-MAINTAIN SERVICES CONTRACT No. CT-DTS1100194. November, 2011. Available at: http://hartdocs.honolulu.gov/docushare/dsweb/Get/Document-14729/Agreement.pdf . Accessed April, 2017.

**Supporting Document # 2.SD4
Part II**

OPERATIONS AND MAINTENANCE

Item	Price (million \$)	Calculations	Source
O&M for 40 Cars	\$83.50	Intermediate O & M (2021 through 2025) $\$167 \text{ M for 80 cars;}$ $\$167 \text{ M} \div 2 = \$83.5 \text{ M for 40 cars}$	HART, Honolulu Authority for Rapid Transportation. AGREEMENT FOR DESIGN-BUILD-OPERATE-MAINTAIN SERVICES CONTRACT No. CT-DTS1100194. November, 2011. Available at: http://hartdocs.honolulu.gov/docushare/dsweb/Get/Document-14729/Agreement.pdf . Accessed April, 2017.

Document attached
Appropriate prices circled

Honolulu High-Capacity Transit Corridor Project

The third NTP ("NTP #3") is anticipated to be issued to construct, install, test and demonstrate the Core Systems operations leading to multiple segment openings for Passenger Service, as is defined in Part 2, Special Provisions ("SP") SP-4.1.

Subsequent NTPs may be issued for commencement of operations and maintenance and for Work identified in Contract amendments. All NTPs shall be issued in support of the accepted Baseline Schedule (as Proposed) in compliance with the schedule required dates defined in SP-4.1 and attached to this Contract in Part 9.

5. This is a firm fixed-price contract, and subject to the provisions of this paragraph and in accordance with Chapter 6 of the GCDB, as amended by Chapter 6 of the Special Provisions, HART agrees to pay the CORE SYSTEMS CONTRACTOR, for the satisfactory performance and completion of the Work, the payments in accordance with the Schedule of Milestones. The aggregate amount of these lump sum payments shall not exceed ONE BILLION THREE HUNDRED NINETY-SEVEN MILLION THREE HUNDRED EIGHTY-SEVEN THOUSAND NINETY-THREE AND 00/100 DOLLARS (\$1,397,387,093.00). The lump sum payments for services and the Work performed under the Contract are all inclusive of direct labor, overhead, general and administrative expenses, other direct costs, subcontractor costs, fixed fees, and all applicable taxes, State general excise and use tax (GET) and county one-half percent (0.5%) GET Surcharge.

The total lump sum payments consist of the following:

\$573,782,793 for the Design-Build lump sum;
\$166,974,503 for Intermediate O&M periods;
\$339,056,303 for the first full five-year O&M period;
\$317,573,494 for the optional five-year O&M period unless terminated by HART.

At the end of the first full five-year O&M period, the CORE SYSTEMS CONTRACTOR's O&M performance on the O&M portion of the Work will be evaluated by HART. HART may terminate the Agreement at the end of the first full five-year O&M period without any further obligations to HART if HART, in its sole discretion, determines that the CORE SYSTEMS CONTRACTOR's O&M performance is unsatisfactory. Such termination of the Agreement shall be in writing from HART to the CORE SYSTEMS CONTRACTOR. Any funds remaining at the end of this Agreement shall revert back to HART.

In accordance with the paragraphs above, the total aggregate amount of ONE BILLION THREE HUNDRED NINETY-SEVEN MILLION THREE HUNDRED EIGHTY-SEVEN THOUSAND NINETY-THREE AND 00/100 DOLLARS (\$1,397,387,093.00) is established as the maximum payable under this Contract and is subject to the Special Provisions and the GCDB, including the provisions thereof relating to reducing or increasing the compensation of the CORE SYSTEMS CONTRACTOR.

6. By signing below, the CORE SYSTEMS CONTRACTOR hereby certifies that, to the best of its knowledge and belief, cost or pricing data, as defined in Section 3-122-122, HAR, and submitted pursuant to Section 3-122-125, HAR, is accurate, complete, and current as of the date of this Contract.

7. Unless otherwise agreed in writing when notice is to be given to HART, it shall be mailed or delivered to:

Supporting Document # 2.SD5
Part II

STATIONS

Item	Price (million \$)	Calculations	Source
Stations	\$433.80	For 12 stations; Sum of all stations from "Pearl Harbor" to "Ala Moana"	HART, Honolulu Authority for Rapid Transportation. Interim Plan. Available at: http://hartdocs.honolulu.gov/docushare/dsweb/Get/Document-19327/20160930-hart-interim-plan.pdf . Accessed April, 2017.

Document attached
Appropriate prices circled

September 2016

Option #3

Construct Project as far as funding allows

Actual or Estimated Cost of Each Station

East Kapolei	\$ 17.7M	Airport	\$ 32.5M
UH West O'ahu	\$ 22.2M	Lagoon Drive	\$ 22.3M
Ho'opili	\$ 14.1M	Middle Street	\$ 45.9M
West Loch	\$ 41.0M	Kalihi	\$ 30.2M
Waipahu	\$ 35.2M	Kapalama	\$ 33.0M
Leeward CC	\$ 12.0M	Iwilei	\$ 31.8M
Pearl Highlands TC	\$ 280.0M	Chinatown	\$ 41.1M
Pearl Highlands	\$ 47.1M	Downtown	\$ 60.1M
Pearlridge	\$ 36.4M	Civic Center	\$ 37.4M
Aloha Stadium	\$ 30.5M	Kaka'ako	\$ 27.9M
Pearl Harbor	\$ 26.0M	Ala Moana	\$ 45.6M

EXHIBIT F

H O N O L U L U R A I L T R A N S I T P R O J E C T
www.honolulurail.org

HART
H O N O L U L U A I R T R A N S I T A U T H O R I T Y

**Supporting Document # G.SD1
General**

PEARL HIGHLAND TRANSIT CENTER - BUS SERVICES

Item	Price (million \$)	Calculations	Source
Pearl Highland Transit Center - Bus Services	\$280.00	1 Bus Depot	HART, Honolulu Authority for Rapid Transportation. Interim Plan. Available at: http://hartdocs.honolulu.gov/docushare/dsweb/Get/Document-19327/20160930-hart-interim-plan.pdf . Accessed April, 2017.

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Leeward CC	\$ 12.0M	Iwilei	\$ 31.8M
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Aloha Stadium	\$ 30.5M	Kaka'ako	\$ 27.9M
Pearl Harbor	\$ 26.0M	Ala Moana	\$ 45.6M

EXHIBIT F

HONOLULU RAIL TRANSIT PROJECT
WWW.HONOLULUTRANSIT.ORG

HART
HONOLULU AUTHORITY - RAIL TRANSIT

Supporting Document # G.SD2
General

PROFESSIONAL SERVICES

Item	Price (million \$)	Calculations	Source
Professional Services	\$1,123.00	May need downward revision with revised outlook	HART, Honolulu Authority for Rapid Transportation. Rail Facts. Available at: http://hartdocs.honolulu.gov/docushare/dsweb/Get/Document-18755/201603-rail-update-hart-facts.pdf . Accessed April, 2017

Supporting Document # G.SD3
General

R-O-W ACQUISITION

Item	Price (million \$)	Calculations	Source
R-O-W Acquisition	\$198.00	-	HART, Honolulu Authority for Rapid Transportation. Rail Facts. Available at: http://hartdocs.honolulu.gov/docushare/dsweb/Get/Document-18755/201603-rail-update-hart-facts.pdf . Accessed April, 2017

Supporting Document # G.SD4
General

FINANCE CHARGE

Item	Price (million \$)	Calculations	Source
Finance Charge	\$215.00	-	HART, Honolulu Authority for Rapid Transportation. Rail Facts. Available at: http://hartdocs.honolulu.gov/docushare/dsweb/Get/Document-18755/201603-rail-update-hart-facts.pdf . Accessed April, 2017

Document attached
Appropriate prices circled



HONOLULU AUTHORITY FOR RAPID TRANSPORTATION

HART FACTS—MARCH 2016

HART CEO Dan Grabauskas answers community questions about rail transit.

QUESTION:

What is the status of the production of HART's rail vehicles?

DAN GRABAUSKAS:

Our first four rail cars are in final assembly at the Hitachi plant in Pittsburg, California and are scheduled to be delivered here in Honolulu during the last week of this month. Our 4-car trains will be air conditioned, and passengers will have free Wi-Fi access. Trains will run from 4 a.m. to midnight and will arrive at stations every 5 minutes during the morning and evening rush hours, and every 11 minutes during the rest of the day. Each train will be equipped with safety and security features, including closed-circuit television cameras and call boxes. Passengers will be able to bring luggage, strollers, bicycles and surf boards aboard. The cars will undergo some initial testing at the Rail Operations Center in Waipahu.

PROJECT REVENUE STATUS

As of February 1, 2016

REVENUE SOURCE:	Projections to Date ¹ (in millions)	Collected or Committed to Date (in millions)	Percentage (of projections)
Project Beginning Cash Balance (Dec. 2009)	\$ 298	\$ 298	100%
General Excise Tax (GET) Surcharge ²	3,291	1,259	38%
Federal New Starts Funds	1,550	1,056	68%
Other Federal Transportation Funds	214	4	2%
Interest Income	2	9	—
TOTAL	\$5,355	\$2,626	49%

1 - Projections to date from the June 2012 Financial Plan.

2 - Total GET surcharge revenue collected since January 1, 2007, is \$1.59 billion (includes \$378 million collected before December 2009).

PROJECT COST STATUS

As of February 1, 2016

	Current Budget ¹ (in millions)	Amount Committed ² (in millions)	Amount Expended ³ (in millions)
Guideway & Track Elements	\$1,159	\$ 550	\$ 292
Stations, Stops, Terminals, Intermodal	419	302	5
Support Facilities, Yards, Shops, Admin	115	115	92
Sitework & Special Conditions	1,007	730	569
Systems	249	234	40
Vehicles	191	191	36
SUB-TOTAL*	\$3,140	\$2,122	\$1,033
Right-of-Way (ROW), Land, Existing Improvements	\$ 198	\$ 104	\$ 100
Professional Services (e.g., Planning and Design)	(1,123)	1,049	787
Contingency	487	7	1
Finance Charges	215	0	0
SUB-TOTAL*	\$2,024	\$1,160	\$ 888
TOTAL*	\$5,164	\$3,282	\$1,921

1 - Current Budget reflects the June 2012 Baseline Budget with executed Budget Transfers.

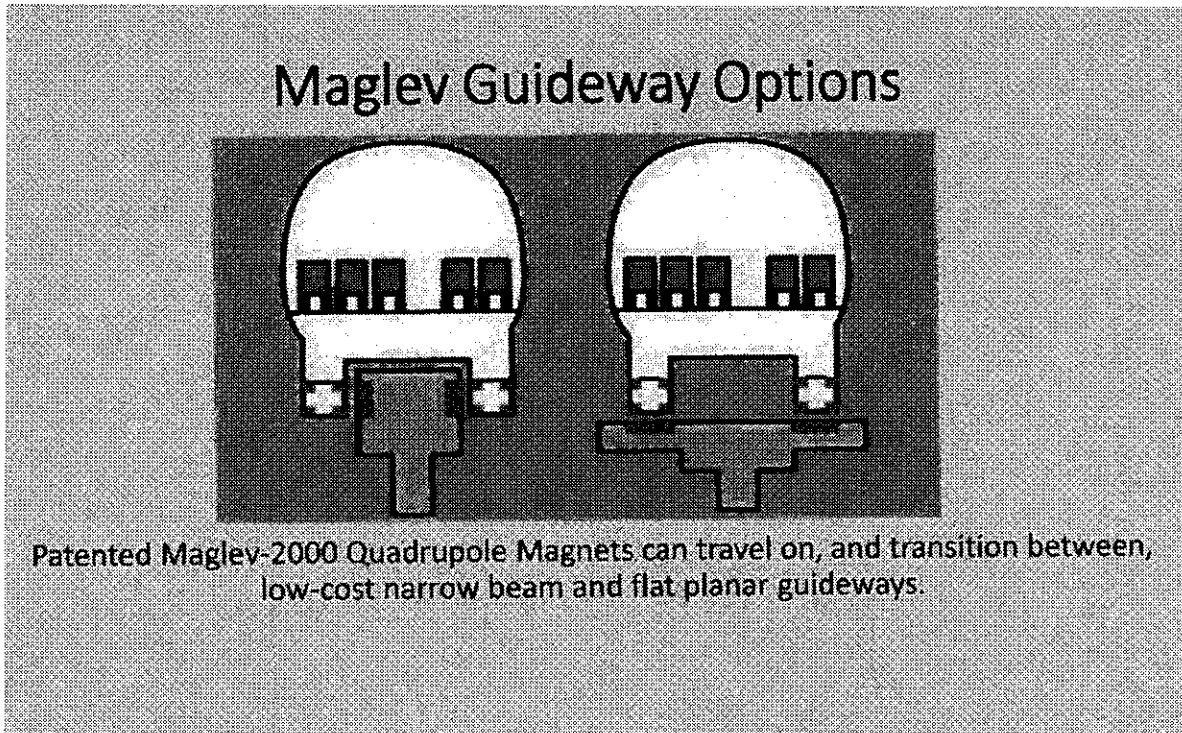
2 - Approved contract value. 3 - Portion of the work that has been paid.

* All costs are rounded to the millions therefore subtotals may not add up to the amounts shown.

DID YOU KNOW? HART has ordered a fleet of 80 rail cars.

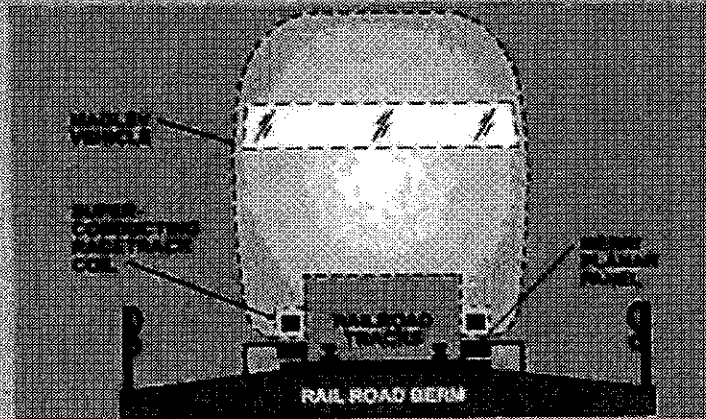
APPENDIX

Maglev Guideway Options



Maglev on Standard Gauge Rail

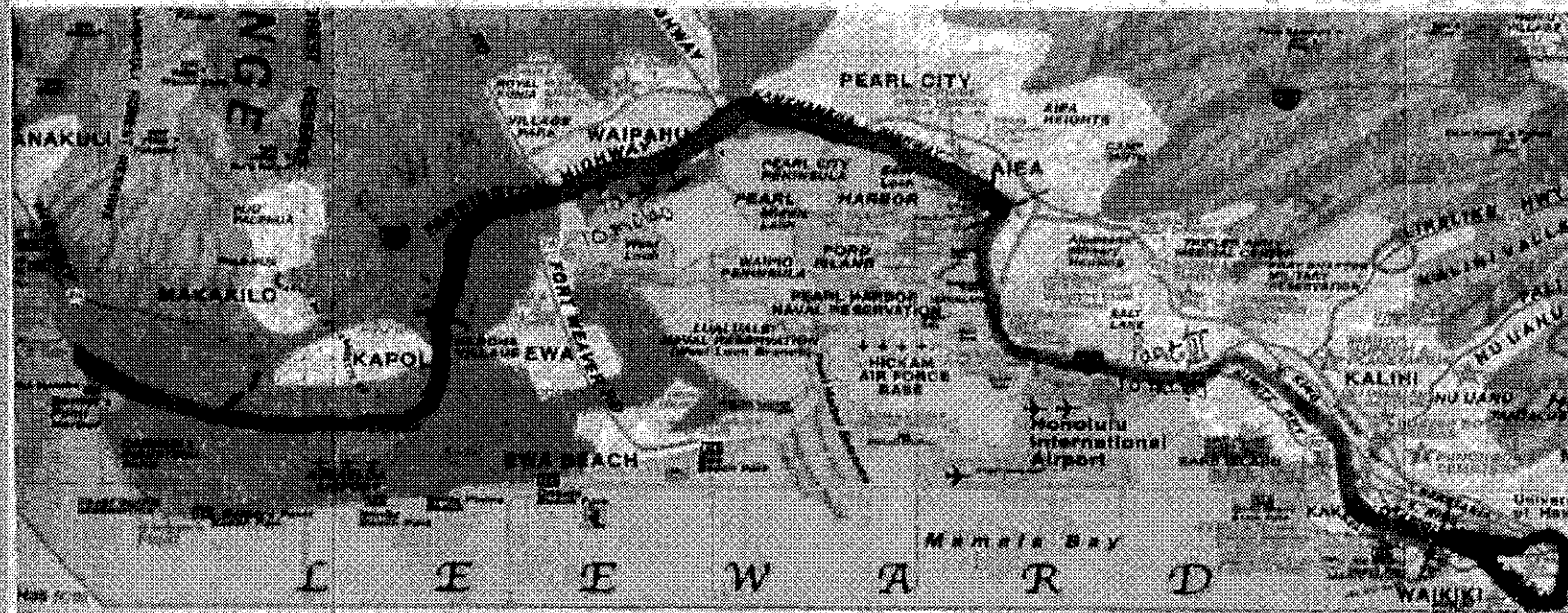
Maglev on Standard Gauge Rail



Conversion of a steel wheels on steel rails guideway to accommodate an urban maglev as well as a conventional train.

MERRI: Maglev Replacement on RailRoad Infrastructure

A 32-mile Maglev Rail Alignment



STEEL WHEELS GUIDEWAY

MAGLEV EXTENSION

WEST KAPOLEI EXTENSION

ONE-WAY TO WAIKIKI/UH

Honolulu Rail Map